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Polyporus Tomentosus Root Rot of Conifers

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Black spruce and white spruce killed by *Polyporus tomentosus* in a 65-year-old stand near Candle Lake in north-central Saskatchewan.

**FISHERIES AND ENVIRONMENT CANADA
CANADIAN FORESTRY SERVICE
GREAT LAKES FOREST RESEARCH CENTRE
SAULT STE. MARIE, ONTARIO**

Forestry Technical Report No. 18

INTRODUCTION

Polyporus tomentosus Fr. is one of the most widespread root-rotting fungi in the boreal forest. Information from various sources has been summarized in this publication to provide forest managers with a reference to biological aspects and control of *P. tomentosus* when they encounter damage in spruce stands. Hosts, distribution, recognition of the fungus, and damage caused by it are discussed. Life-cycle data and recommendations for control are presented. As early as 1922, Faull (6) described the white pocket root rot of white pine (*Pinus strobus* L.) and other conifers in Canada. Hubert (10) and Christensen (4) noted its occurrence in the United States somewhat later. *Polyporus tomentosus* has since been identified as a cause of butt rot in many Canadian conifers and more recently as a cause of mortality in spruces (20, 24).

HOSTS AND DISTRIBUTION

Polyporus tomentosus or the variety *P. tomentosus* var. *circinatus* Fr. occurs throughout the temperate zones of the northern hemisphere (1, 5, 20). To the author's knowledge, it has not been reported from Africa or the southern hemisphere. In North America the variety, *P. t. circinatus*, has been reported from as far south as Georgia (14), and *P. tomentosus* from as far north as Lake Athabasca, Saskatchewan (27). In Asia, *P. tomentosus* is found in the Himalayas of northern India (1).

There are no authentic reports of natural infection of hardwood species, but successful inoculations (22) have been made on white birch (*Betula papyrifera* Marsh.) and trembling aspen (*Populus tremuloides* Michx.).

CANADA: All native species of spruce and most species of pines are attacked. Other native species attacked include:

<i>Abies amabilis</i> (Dougl.) Forbes	amabilis fir
<i>Abies balsamea</i> (L.) Mill.	balsam fir
<i>Abies lasiocarpa</i> (Hook.) Nutt.	alpine fir
<i>Larix laricina</i> (Du Roi) K. Koch	tamarack
<i>Larix occidentalis</i> Nutt.	western larch
<i>Pseudotsuga menziesii</i> (Mirb.) Franco	Douglas-fir
<i>Thuja plicata</i> Donn.	western red cedar
<i>Tsuga canadensis</i> (L.) Carr.	eastern hemlock
<i>Tsuga heterophylla</i> (Raf.) Sarg.	western hemlock

In general, spruces are more susceptible than pines, and tamarack is very susceptible (22).

UNITED STATES: In addition to species common to Canada, the following are infected in the United States (9):

<i>Abies procera</i> Rehd.	noble fir
<i>Picea pungens</i> Engelm.	blue spruce
<i>Pinus elliotii</i> Engelm.	slash pine
<i>Pinus radiata</i> D. Don.	Monterey pine
<i>Pinus rigida</i> Mill.	pitch pine
<i>Pinus taeda</i> L.	loblolly pine

EUROPE: Besides the three species listed, numerous exotic conifers, including North American species, are attacked:

Picea abies (L.) Karst.
Pinus nigra Arnold
Pinus sylvestris L.

Norway spruce
Austrian pine
Scots pine

INDIA (1):

Cedrus deodara Roxb.
Picea smythiana Boiss.

deodar cedar
Indian spruce

DAMAGE

Although *Polyporus tomentosus* attacks many coniferous species (18), damage in Canada is greatest in white spruce (*Picea glauca* (Moench) Voss) and black spruce (*P. mariana* (Mill.) B.S.P.) (2, 18, 20, 25), and in the United States in white spruce and red pine (*Pinus resinosa* Ait.) (11, 13). Information on damage caused and on the causal fungus is therefore based largely on studies of these three species.

Remeasurement of permanent sample plots in 60-year-old natural white spruce on sites susceptible to root rot in Saskatchewan has revealed that, after 10 years, many additional trees had died from *P. tomentosus* root rot or had shown disease symptoms, and that basal area had declined an average of 12% (26). In Ontario, where losses due to root rot have been estimated at 38% and 20% of gross merchantable volume in black spruce and white spruce, respectively, *P. tomentosus* was the second most abundant fungus (next to *Armillaria mellea* (Vahl ex Fr.) Kummer) in the roots (25). Plantations are also affected. In a 40-year-old white spruce plantation in Wisconsin, an average of 2.3% of the dominant and codominant white spruce were killed annually by *P. tomentosus* over a 4-year period (11). Mortality due to *P. tomentosus* root rot has also been observed in 20- to 50-year-old white spruce plantations at Petawawa and Searchmont in Ontario, and at Grand-Mère in Quebec (12). In Saskatchewan, 16% of white spruce seedlings planted around diseased larger trees were killed by *P. tomentosus* or badly diseased after 16 years (24).

Four types of damage result from attack by *P. tomentosus* on tree roots (25): outright mortality, premature windfall, growth slowdown, and butt cull. Dead trees occur either singly (Fig. 1) or in groups (Fig. 2); distinct openings in the stand may result (Fig. 3). Death in natural stands usually occurs in trees more than 50 years of age, but trees as young as 19 years have been killed by *P. tomentosus* (24). Trees of all crown classes are affected. Structural weakening of the root system by *P. tomentosus* greatly increases the susceptibility of a tree to windfall, and represents the greatest damage caused by this fungus. The gradual killing of roots by *P. tomentosus* over a period of years results in a reduction of height and diameter increments (7, 20). Dominant or co-dominant trees, if they are in a sheltered position, may live on in a moribund condition for many years. The loss in increment due to root rot in such trees can be considerable (25). *Polyporus tomentosus* often extends several metres up the stem in black and white spruce, necessitating butt cull and resulting in volume loss in affected trees.



Figure 1 — Sixty-year-old white spruce killed by *Polyporus tomentosus* root rot near Candle Lake, Saskatchewan.



Figure 2 — Dead white spruce trees killed by *P. tomentosus* in a 65-year-old stand near Candle Lake, Saskatchewan.



Figure 3 — Windfallen 80-year-old black spruce trees in a typical stand opening caused by *P. tomentosus* in northwestern Ontario.



Figure 4 — Moribund white spruce with heavy root rot caused by *P. tomentosus*.

RECOGNITION

Root rot caused by *Polyporus tomentosus*, like that caused by most fungi that advance slowly in the root system, results in trees with excessive branch mortality from below, shortened height and lateral increment, and general thinning of the crown (Fig. 4). These symptoms, when accompanied in late summer by the light brown, pored *P. tomentosus* (hymenial setae straight) sporophores (Fig. 5) on the ground near the tree, or the shelf-like *P. tomentosus* var. *circinatus* sporophores (hymenial setae curved or strongly hooked (8)) on the base of affected trees (Fig. 6), are definite proof of the presence of *P. tomentosus* root rot. The sporophores are sparse or absent if the summer has been dry. In the absence of sporophores, as in early summer or in dry years, *P. tomentosus* root rot can be suspected if there are dead, standing (Fig. 1) or criss-crossed, windfallen dominant or codominant trees (Fig. 3) that were not obviously killed by suppression, insects, or other agencies such as fire, hail, high water, porcupines, etc. The presence of reddish-brown stain (Fig. 7) or yellow or white pockets (Fig. 8) in root wood, and basal resinosis of such affected trees, indicates *P. tomentosus* as the cause. In the absence of sporophores, however, identification of the causal fungus can be made only by culturing it on artificial nutrient media. In culture, *P. tomentosus* grows slowly, averaging about 2 mm per day on standard malt extract media, and typically forms a brown or whitish-brown cottony mat (Fig. 9), but mat color and texture can vary greatly. Microscopically, the hyphae usually have thick-walled chlamydospores and thin-walled hyphal swellings, and there are no clamp connections. If identification is in doubt, fresh specimens about 20 cm long by at least 5 to 10 cm in diameter from affected roots of green windfalls or suspect standing trees may be sent to one of the forest research centres listed at the end of this report for determination of the presence of this fungus.

LIFE CYCLE

Most of the existing information on host-parasite interaction with *Polyporus tomentosus* has been acquired from natural spruce stands in Canada or from plantations in Quebec or the northern United States.

Natural infection appears to occur below ground. Inoculation experiments indicate that both basidiospores and mycelium within a woody substrate are capable of propagating the disease (21, 23), and that a wound to the cambium or deeper facilitates infection. The main spread within natural stands is by root contacts in which mycelium grows from a diseased root onto a healthy root to which it is tightly appressed (11, 20). Dead, deformed roots resulting from poor planting practices lead to infection (12). Infection from diseased roots within the soil can continue for at least 15 to 20 years following the death of the host. Hence, where the disease occurs naturally, there is an abundance of inoculum in the old remaining roots to infect succeeding generations of trees. The disease is probably transmitted over long distances by wind-disseminated basidiospores even though attempts to infect cut stump surfaces artificially with spores have failed with both spruce and pine. Sporophores are produced in abundance in wet years and millions of basidiospores are produced under a wide range of climatic conditions (3).



Figure 5 — Typical stipitate sporophores of *P. tomentosus*.



Figure 6 — Sessile sporophores of *P. tomentosus*, variety *circinatus*, on the base of a diseased living white spruce tree.

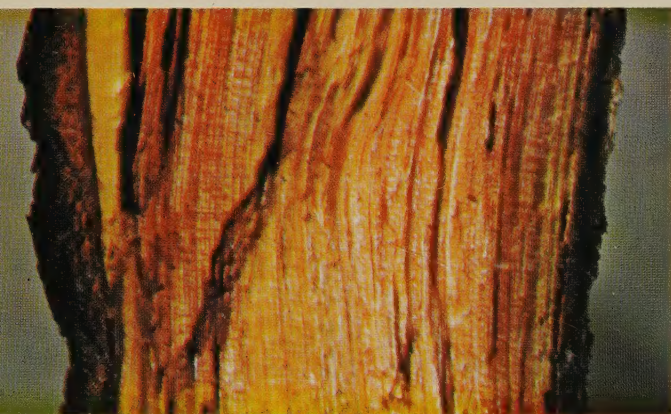


Figure 7 — Reddish-brown stain caused by *P. tomentosus* in a living white spruce root.

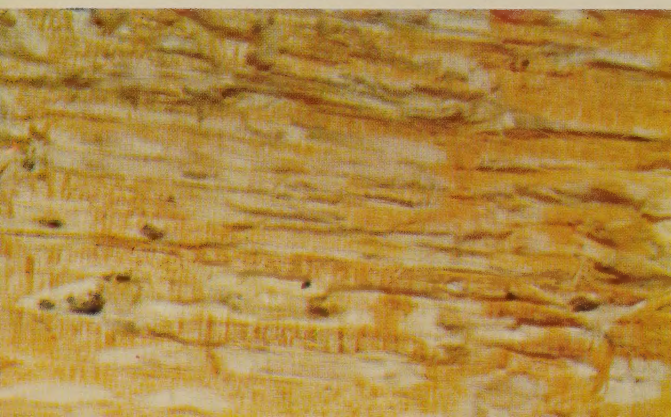


Figure 8 — White pockets of the advanced stage of decay of *P. tomentosus* in root wood.

Once infection occurs, the mycelium grows through the root wood and bark (Fig. 10) both distally and proximally, eventually spreading throughout the major roots and butt of the tree (Fig. 11). The originally infected root usually dies first, but as succeeding large roots are killed and the root collar area becomes heavily invaded, girdling occurs and the tree dies. Growth of the fungus is slow (1 to 10 cm per year in spruce in Saskatchewan), and at least 15 to 20 years usually elapse between infection and tree death (20). Large trees can exist for several decades with heavy root rot; smaller trees, of course, would be girdled sooner. As the fungus advances, the wood becomes stained a reddish brown at first; then small yellow pockets, and eventually white pockets, develop within the stained area (Fig. 8). As decay becomes more advanced, the pockets increase in size and the wood becomes extremely porous, soft, and weak.

An unknown number of years after infection, but well before the tree dies, the annual tan-to-dark-brown, pored sporophores of the fungus (Fig. 5) grow from infected roots to the surface of the soil where they release the basidiospores. The sporophores may grow outward from the lower trunk as well forming a shelf-like conk (Fig. 6). This is the usual type of fruiting of the variety *circinatus*. Fruiting occurs annually for several years after death of the tree.

STAND MANAGEMENT TO REDUCE LOSSES

Root rot caused by *Polyporus tomentosus* occurs in spruce on a variety of sites, including well-drained, upland glacial tills. However, the disease is most prevalent in spruce where soils are very acidic (pH 4-5) and low in nutrients and moisture-holding capacity, and where rooting depth is restricted by shallow or compact soils (15). Heavy attack by root weevils in the *Hylobius* complex, which favor sites with deep moist duff (16) create infection courts for *P. tomentosus* and other root-rotting fungi (17, 19, 20). If the above conditions prevail, future losses from *P. tomentosus* root rot can be minimized by clear cutting the spruce and converting the stand to less susceptible tree species such as pines or balsam fir, or to hardwoods. In plantations, planting techniques that lead to deformed roots should be avoided (12).

Since there is no direct control for this disease, stands should be clear cut as soon as infected trees are found, or as soon as practicable thereafter, to keep losses to a minimum. When dominant trees killed by *P. tomentosus* are found in a stand, many nearby trees will undoubtedly be infected by the fungus. Cutting only the trees with aboveground symptoms will not prevent spread of the fungus to the remaining trees. The entire stand should be cut and the area regenerated with less susceptible species.

The forest research centres in Canada where inquiries may be sent are listed below:

Newfoundland Forest Research
Centre

Canadian Forestry Service
Fisheries and Environment Canada
Building 304, Pleasantville
P.O. Box 6028
ST. JOHN'S, Newfoundland
A1C 5X8

Laurentian Forest Research Centre
Canadian Forestry Service
Fisheries and Environment Canada
P.O. Box 3800,
1080 Route du Vallon
STE. FOY (Quebec 10), P.Q.
G1V 4C7

Pacific Forest Research Centre
Canadian Forestry Service
Fisheries and Environment Canada
506 West Burnside Road
VICTORIA, B.C.
V8Z 1M5

Maritimes Forest Research Centre
Canadian Forestry Service
Fisheries and Environment Canada
P.O. Box 4000
College Hill
FREDERICTON, N.B.
E3B 5G4

Northern Forest Research Centre
Canadian Forestry Service
Fisheries and Environment Canada
5320 - 122 Street
EDMONTON, Alberta
T6H 3S5

Great Lakes Forest Research
Centre
Canadian Forestry Service
Fisheries and Environment Canada
P.O. Box 490, 1219 Queen St. East
SAULT STE. MARIE, Ontario
P6A 5M7

SUMMARY

Polyporus tomentosus is widespread on conifers in the north temperate zone. It causes root rot in at least 31 commercial tree species in eight or more genera, attacking chiefly the xylem of the roots and lower stem, although it may kill the bark as well. In North America, mortality in white and black spruce is most common. Although older trees are killed more frequently than younger ones, white spruce as young as 19 years succumb to the disease. Local spread of the disease is chiefly through root contacts; groups of dead trees create gaps or openings in the stand. Both natural stands and plantations are affected. The disease is most severe where rooting is restricted by shallow or impervious soils that are acidic and have a deep layer of undecomposed duff, especially where roots are deformed. Fruiting of the fungus occurs from midsummer through autumn and the annual sporophores produce spores most abundantly under moist conditions and above-freezing temperatures. The role of spores in the natural spread of the disease is not well understood. The variety *P. t. circinatus* seems to occur throughout the range of the species, but inoculation experiments indicated that the variety is less pathogenic than the form with straight setae.

There is no direct control for *P. tomentosus* root rot. Losses can be kept to a minimum by harvesting the entire stand as soon as serious mortality and/or windfall begin among the crop trees. Less susceptible species such as pines or hardwoods should be used on sites where spruces are badly damaged. Care must be taken in planting to avoid development of deformed roots.

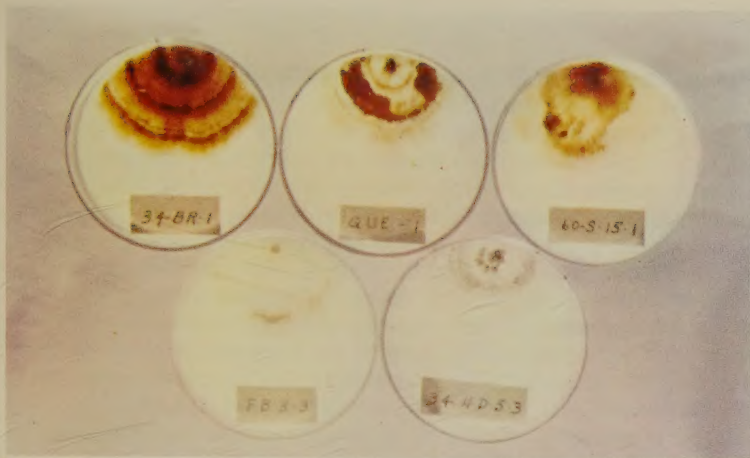


Figure 9

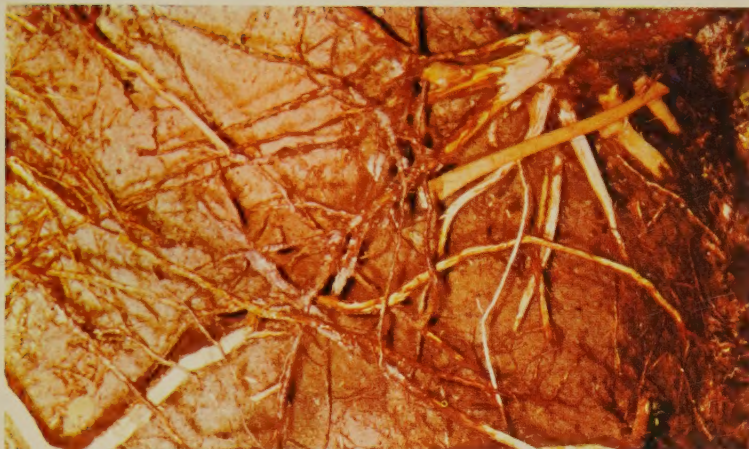


Figure 10



Figure 11

Figure 9 — Six-week-old cultures of *P. tomentosus* on mineral dextrose medium.

Figure 10 — Large white spruce root (bark removed) killed by *P. tomentosus* on a 45-year-old tree. Stain and decay extended well into the butt and distally in the centres of other large roots.

Figure 11 — *P. tomentosus* root rot which has extended from the infected roots to the butt of a 45-year-old living white spruce tree.

Polyporus tomentosus est un agent très répandu de la carie des racines des conifères dans la zone tempérée nord. Il cause une carie de racine dans le cas d'au moins 31 essences arborescentes commerciales de haut genres ou plus; il s'attaque au duramen des racines et du bas de la tige, mais il peut aussi faire mourir l'écorce. En Amérique du Nord c'est dans le cas de l'épinette noire et de l'épinette blanche que la mortalité est la plus élevée. Même si les vieux arbres sont plus fréquemment tués que les jeunes, la maladie peut faire mourir l'épinette blanche dès l'âge de 19 ans. La progression locale de la maladie s'effectue surtout par contact des racines; les groupes d'arbres morts créent des trouées dans les peuplements. Les peuplements naturels comme les plantations peuvent être atteints par l'infection. La maladie est plus grave si l'enracinement est restreint par la faible épaisseur ou l'imperméabilité du sol et si le sol est acide et comporte une couche épaisse de matière organique non décomposée; elle est d'autant plus grave si les racines sont déformées. Le champignon fructifie depuis le milieu de l'été jusqu'à l'automne et les sporophores annuels produisent davantage de spores dans les environnements humides. Le rôle joué par les spores dans la propagation naturelle de la maladie est mal compris. La variété *P. t. circinatus* semble présente dans toute l'aire de l'espèce, mais des expériences d'inoculation indiquent qu'elle est moins pathogène que *P. tomentosus*. Il n'y a pas de méthode directe de répression de la carie de la racine causée par *P. tomentosus*. Il est possible de minimiser les pertes en récoltant le peuplement entier dès qu'il commence à y avoir beaucoup de mortalité ou de chablis parmi les arbres prêts à récolter. Il y a lieu d'employer des essences plus résistantes comme les pins ou les feuillus sur les stations où les épinettes sont gravement atteintes. Lors de la plantation, il faut éviter les pratiques amenant une déformation des racines.

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Polyporus tomentosus sporophores near the base of a heavily diseased but still living 50-year-old white spruce.

Production supervision: C. A. Plexman

Photography: R. D. Whitney

Printing: Sault Star Printing

Issued under the authority of the Minister
Fisheries and Environment Canada
Minister of Supply and Services Canada
1977

Catalogue No. Fo64-18/1977

ISBN 0-662-00634-8

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